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博士学位论文

闽南近海条纹斑竹鲨 (*Chiloscyllium plagiosum* Bennett, 1830) 脂肪酸的研究

Studies on Fatty Acid of White-Spotted Bamboo Shark,  
*Chiloscyllium plagiosum* (Bennett 1830), from  
Southern Fujian Coast Waters

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## 中文摘要

本论文主要研究闽南近海条纹斑竹鲨 (*Chiloscyllium palgiosum*) 的生物学、肝体指数 (*LSI*) 和肝脏脂肪的理化常数、肝脏、软骨和肌肉的含水率、含油率及其脂肪酸组成以及季节变化和个体发育对水分和脂肪组成的影响, 同时也比较了不同组织间的成分差异。通过本文的研究, 将查清条纹斑竹鲨的软骨、肌肉、肝脏等组织中特定脂肪的含量及其变化, 同时还对条纹斑竹鲨各组织内 EPA (C20:5) 和 DHA (C22:6) 含量进行分析, 为海洋功能性食品和药物研究和开发提供重要参考, 具有较高的理论意义; 研究结果还将对条纹斑竹鲨资源的利用、保护与管理提供科学依据。

主要研究结果如下:

1. 条纹斑竹鲨的体长 (BL) 与体重 (BW) 的关系为:  $BW = 3.0 \times 10^{-6} \times BL^{3.0065}$ , 条纹斑竹鲨属于等速或等比生长的鱼; 肝重 ( $W_{肝}$ ) 与纯体重 ( $W_{纯}$ ) 的关系为: 条纹斑竹鲨 (雌):  $W_{肝} = 67.956W_{纯} - 7.3948$ , 条纹斑竹鲨 (雄):  $W_{肝} = 55.565W_{纯} - 4.1336$ , 肝重与体长的关系为: 条纹斑竹鲨 (雌)  $W_{肝} = 0.4389e^{0.06995BL}$ , 条纹斑竹鲨 (雄)  $W_{肝} = 0.4163e^{0.0711BL}$ 。

2. 闽南近海条纹斑竹鲨群体年龄结构由 0—6 龄鱼组成, 年龄结构较复杂, 2 龄鱼和 3 龄鱼为种群的主要组成, 合计占 53.9%。其他各年龄组成相对比较平均, 其资源利用情况比较合理, 尚没有被破坏。

3. 当纯体重达到 0.45kg 后, 条纹斑竹鲨的肝脏出现明显的雌雄分化 (差异大于  $\pm 10\%$ )。在相同纯体重的情况下, 雌性个体的肝脏重量大于雄性个体的。当体长小于 46cm 时, 雌雄个体之间肝脏重量差别不大 (小于  $\pm 10\%$ )。随着体长的增加, 相同体长雌鱼的肝重大于雄鱼。根据条纹斑竹鲨的年龄结构分布, 纯体重 0.45kg 和体长 46cm 属于 2 龄鱼, 也就是说, 从 2 龄鱼开始肝脏发育出现雌雄分化现象, 性别发育的差异导致雌雄个体对能量需求的不同。

4. 肝脏是条纹斑竹鲨的主要储脂器官, 肝脏内脂肪含量的增加或减少引起条纹斑竹鲨肝体指数的变化。而生殖活动则是引起肝脏内脂肪含量变化的主要原因。条纹斑竹鲨 *LSI* 值的变化范围在 1.82~7.73, 肝脏含油率的变化范围在 15.84~67.63%, 两者都比大多数硬骨鱼大。

5. 条纹斑竹鲨的 *LSI* 值和肝脏含油率都存在明显的季节变化, 而且变化趋势一致, 都是从 10 月开始到翌年的 3 月都比较高, 3 月达到最高, 而后迅速降低, 6 月份最低, 随后变化不大, 这种情况一直保持到 10 月份。条纹斑竹鲨的繁殖高峰期为每年的 3 月~6 月。

6. 条纹斑竹鲨的 *LSI* 值和肝脏含油率在 2 龄鱼开始出现显著的个体差异。对相同年龄的个体来说, 雌性个体的 *LSI* 值和肝脏含油率比雄性个体的 *LSI* 值和肝脏含油率要大, 这个现象与条纹斑竹鲨肝脏发育的雌雄分化一致。而条纹斑竹鲨的生殖腺重量在 1 龄鱼和 2 龄鱼时个体差异不大, 从 3 龄鱼开始出现显著的个体差异, 最大值与最小值相差高达 33 倍, 条纹斑竹鲨的初次性成熟年龄为 3 龄。

7. 条纹斑竹鲨肝脏的含水量有明显的季节变动规律, 这个变动趋势与肝脏含脂量的变动趋势相反: 4 月~6 月条纹斑竹鲨肝脏含水量出现一个明显的波动, 7 月份则急剧下降, 随后几个月肝脏的含水量都比较低, 也就是说, 随着含水量增大, 肝脏内脂肪含量减少, 肝脏内水份和脂肪的总含量保持相对稳定。

8. 随着年龄的增加, 条纹斑竹鲨肝脏的含水量减少而含油量增加, 同时水分和脂肪的总含量略有增加; 肌肉的含水量减少而含油量增加, 但水分和脂肪的总含量变化不大; 软骨内含油量随着含水量的降低而稍有增加, 但水分和脂肪的总含量则略有减少。随着年龄的增加, 条纹斑竹鲨肝脏、肌肉和软骨中的脂肪含量都增加, 其中肝脏的增幅最大, 骨骼内脂肪含量增幅最小; 而水分含量都减少。

9. 条纹斑竹鲨雄性个体肝脏中的不饱和脂肪酸含量稍高于雌性个体, 随着年龄的增加, 雌雄个体肝脏脂肪里不饱和脂肪酸的含量逐渐减少。

10. 1 龄鱼条纹斑竹鲨肝脏脂肪中短链脂肪酸含量最高, 达到性成熟以后, 短链脂肪酸的含量会稍微减少, 雌雄差别不明显。1 龄鱼的肝脏脂肪中游离脂肪酸含量最高, 随着年龄的增加, 肝脏脂肪中游离脂肪酸含量也有减少的趋势。

11. 生殖活动对条纹斑竹鲨肝脏脂肪的化学特性值有很大的影响, 在生殖季节, 条纹斑竹鲨肝脏脂肪的碘价和皂化价下降, 而酸价上升, 由此推断, 生殖活动可能会消耗短链不饱和脂肪酸, 而产生游离脂肪酸。

12. 条纹斑竹鲨体内, 不同组织的脂肪酸组成相似, 但每种组分的含量差

异很大。其中, 条纹斑竹鲨肝油中饱和脂肪酸含量为 25.38~33.35%, 单不饱和脂肪酸含量为 27.17~39.52%, 多不饱和脂肪酸含量为 27.82~45.05%, 肝脏中脂肪酸的主要组成为 C16:0 (17.11%)、C18:1 (15.81%)、C22:6 (11.65%)、C16:1 (11.20%)、C18:3 (7.61%)。肌肉脂肪中饱和脂肪酸含量为 18.58~30.89%, 单不饱和脂肪酸含量为 11.69~20.38%, 多不饱和脂肪酸含量为 45.57~59.74%, 肌肉中脂肪酸的主要组成是 C22:6 (19.09%) 含量最高, 其后依次为 C20:4 (13.32%)、C16:0 (12.83%)、C18:1 (9.93%)、C18:3 (7.41%)、C18:0 (7.07%)。软骨脂肪中饱和脂肪酸含量为 21.15~34.33%, 单不饱和脂肪酸含量为 20.03~29.21%, 多不饱和脂肪酸含量为 21.09~37.41%, 软骨脂肪酸主要组成成分依次为 X-fa (16.58%)、C16:0 (13.29%)、C18:1 (12.90%)、C18:3 (7.87%)、C18:0 (7.82%)。

13. 条纹斑竹鲨体内含有一种长碳链(碳链长度大于 26)的未知脂肪酸 X-fa, X-fa 在条纹斑竹鲨体内的含量分布是有规律的, 其中软骨中 X-fa 含量最高, 含量范围为 7.05~24.60%, 平均为 16.57%, 是软骨内脂肪酸的主要组成成分; 其次是肌肉, 含量范围为 3.32~9.86%, 平均为 5.96%; 肝脏中 X-fa 含量最少, 组成范围为 0.20~2.92%。

14. 生殖活动对条纹斑竹鲨体内的脂肪酸组成有很大的影响。当生殖期来临时, 条纹斑竹鲨肝脏和肌肉中饱和脂肪酸含量都减少, 为生殖活动提供大量的能量, 其中 C16:0 和 C18:0 作用最大。肝油、肌肉和软骨中 C20:4、C20:5 和 C22:6 都表现与生殖活动有很大的相关性。雌雄个体对脂肪酸的需求不同, 雄性个体软骨中 X-fa 含量在生殖期明显下降。

**关键词:** 闽南近海; 条纹斑竹鲨; 脂肪酸

Ph. D. Dissertation of Xiamen University

**Studies on Fatty Acid of White-Spotted Bamboo Shark,  
*Chiloscyllium palgiosum* (Bennett, 1830), from Southern Fujian  
Coast Waters**

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**ABSTRACT**

Southern Fujian Coast Waters Fishing Ground abundant in aquatic resource. In this thesis, total 100 fish specimens were identified and analyzed. Some data are detailed studies, including biology, the liver-somatic index (*LSI*), oil content and water content in liver, muscle and cartilage of white-spotted bamboo (*C. palgiosum*). Total fatty acid composition of liver lipid, muscle lipid and cartilage lipid, with season changes, development stages of fish, the age of fish, and the differences among these organisms are studied as well. The mainly objective of this paper is to investigate the patterns of variation of liver lipids, muscle lipids and cartilage lipids, and their important components, as the same time to provide scientific basis for exploitation and utilization of shark resources off Southern Fujian coastal waters. The contents of EPA and DHA, which are known as bioactive substance, are also analyzed. The main results are as fellows:

1. The relationship between body length (BL) and body weight (BW) could be expressed as  $BW=3.0\times10^{-6}\times BL^{3.0065}$ . In this relationship, exp. is 3.0065, so white-spotted bamboo shark is the closest to a symmetrical one. The relationship

between liver weight and net weight could be expressed as  $W_{\text{liver}} = 67.956W_{\text{NW}} - 7.3948$  for female and  $W_{\text{liver}} = 55.565W_{\text{NW}} - 4.1336$  for male. The relationship between liver weight and body length is  $W_{\text{liver}} = 0.4389e^{0.06995BL}$  for female,  $W_{\text{liver}} = 0.4163e^{0.0711BL}$  for male.

2. The age composition in *C. plagiosum* is very complicated. Age 2 and age 3 are the main part population, but the proportion is not high, other ages make up relatively more average, situation of its utilization of resources is more rational, is not destroyed .

3. When the net weight gets more than 0.45kg, liver of white spotted bamboo shark shows obvious male and female split up (up  $\pm 10\%$ ), with the same net weight the female individual's liver weight is greater than the male individual's. When the body length gets longer than 46cm, liver of white-spotted bamboo shark shows obvious male and female split up (up  $\pm 10\%$ ), with the same body length, the female individual's liver weight is heavier than the male individual's. According to the age composition distribution table of white-spotted bamboo shark, net weight 0.45kg and body length 46cm belong to the fish for age 2, that is to say fish liver development appear male and female phenomenon of splitting up, sex difference of development cause male and female individual demand different to energy from age 2.

4. The liver is a mainly organ of storing the lipid of white-spotted bamboo shark, increasing or decreasing of the lipid content cause the variation of white-spotted bamboo shark's *LSI*, reproduction activity might be the main reason to making the liver lipid content change. *LSI* of white-spotted bamboo shark changes from 1.82 to 7.7, liver lipid content changes from 15.84% to 67.63%, both are more than the most of teleosteans, and less than the pelagic elasmobranchs.

5. Significant seasonal variation in the *LSI* and liver lipid content are found in both mature males and females, moreover the change tendency is consistent. Maximum values reached in March and minimum values in June. The apparent seasonal variation in the *LSI* of immature specimens was not statistically significant. The climactic reproductive season of white-spotted bamboo shark (*C. plagiosum*)



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